Geomagnetism in Finland: the lasting legacy of Johan Jakob Nervander

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In the early 19th century electromagnetism was born as magnetism and electricity were found to be closely related to each other. Hans Christian Oersted demonstrated that an electric current causes forces that deflect a magnetic needle. André Marie Ampere discovered the electric current generated in a closed circuit by a changing magnetic field. This effect of magnetic induction offered a new paradigm for geomagnetism, a new solution to an old riddle: *what is the cause of the Earth's magnetism?* Is it a huge electromagnet sustained by internal process of magnetic induction?

Inspired by such questions British, French, German and Russian scientists set up about 20 magnetic observatories throughout the world. In Europe the so-called Magnetic Union was founded by Gauss and Weber in Göttingen to organise coordinated magnetic observatory campaigns. To reveal the significance of magnetic variations, simultaneous magnetic recordings made with similar observatory equipment were needed.

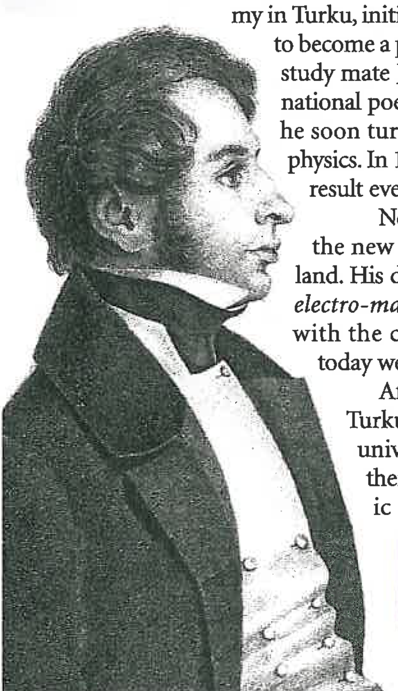
Today there are about a hundred observatories. The basic principles of magnetic observatory measurements remain as they were 160 years ago.

Finland's father of geomagnetism

Johan Jakob Nervander (1805-1848) studied at the Royal Academy in Turku, initially in the humanities. He aspired to become a poet, but the competition with his study mate Johan Ludvig Runeberg, later the national poet of Finland, was formidable and he soon turned to the sciences, particularly physics. In 1827 he matriculated with the best result ever recorded in Turku (Fig. 1).

Nervander was the first promoter of the new electromagnetic science in Finland. His doctoral dissertation *In doctrinam electro-magnetismi momenta* (1829) dealt with the construction of a device which today we call a galvanometer.

After witnessing the Great Fire in Turku he took part in the move of the university to Helsinki in 1828. It was there that he made his main scientific contributions. With the support of a travelling studentship, he made an extensive tour of Europe between 1832 and 1836, visiting the leading laboratories in Sweden, Denmark, Germany, France and Italy. Geomagnetism became his main interest. In Paris he lectured on the construction of a new galvanometer, his *tangentbussol.* Careful calibration of the new instrument showed that the tangent of the deflection angle of the magnetic needle was proportional to the current to be measured. Nervander's *tangentbussol* is still on display in the Arppeanum, the Helsinki University Museum (Fig. 2).

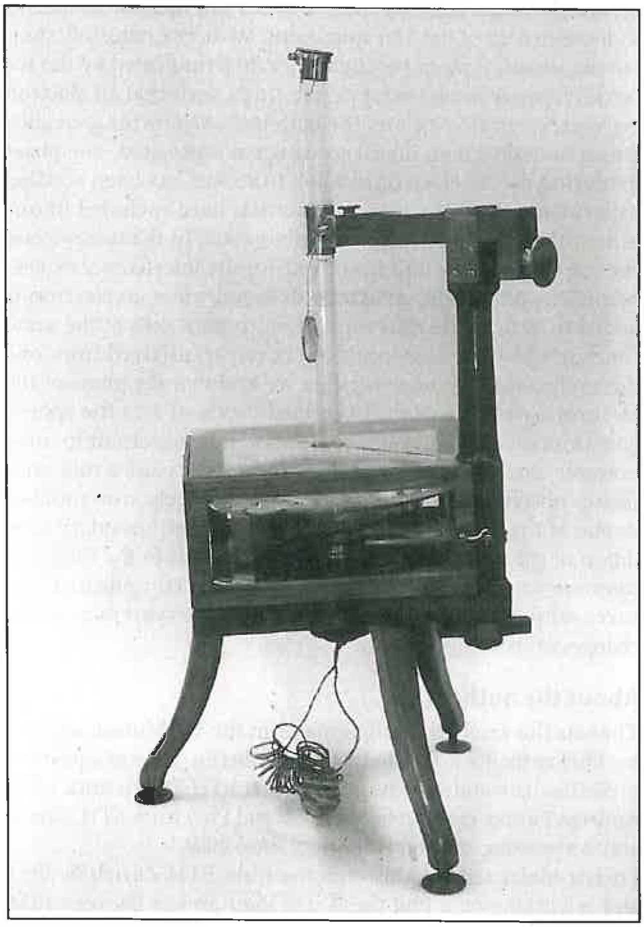


▲ **Fig. 1:** Johan Jakob Nervander (1805-1848).

The foundation of the magnetic observatory

Nervander returned home via St. Petersburg, as the ice conditions made the voyage from Stockholm to Helsinki unpredictable. In St. Petersburg he met Academician Adolf Kupffer, who was to support his ambitions for an observatory in Helsinki.

Since the 1820s several magnetic observatories had been set up in Russia ranging across an area from St. Petersburg on the Baltic Sea to Sitka, Alaska, in the northern Pacific Ocean. Discussions in St. Petersburg pointed to Helsinki as a possible place for an observatory, extending the Russian network. The correspondence between Adolf Kupffer, the director of the Russian Science Academy in St.. Petersburg, and Gustaf Gabriel Hällström, Professor of Physics at the university in Helsinki, and then later with Nervander, shows how this project took shape.



▲ **Fig. 2:** Nervander's *tangentbussol* (galvanometer). Nervander gave a report on this construction in 1833 while in Paris. The apparatus was damaged during the bombings of Helsinki in the war 1944 and the glass parts are replaced. Helsinki University Museum.

In 1838 the university in Helsinki received a letter from its Chancellor expressing that His Imperial Highness approved the founding of a Magnetic Observatory in Helsinki in association with the university.

It was decided to build the Magnetic Observatory in a corner of the Central Park (Kaisaniemi Park) in Helsinki. The assigned architect, Engel, drew up the first plans for a large building for staff and the director's family, together with a smaller one for the calibration of the magnetic instruments (Figs. 3 and 4). Nervander was to be allowed to keep cattle for his own use on the condition their smell would be of no nuisance to the people walking in the park.

As the first Director of the Magnetic Observatory he also had the title of Extraordinary Professor at the university. The personnel under his direction numbered twelve, more than in any other institute at the university.

When the magnetic measurements started in July of 1844, the readings of the instruments were taken every ten minutes. This ambitious programme was followed during the years 1844-1856. After that the readings were taken once per hour and, finally, between 1897 and 1911, only three times per day. In parallel with the magnetic measurements, full-scale meteorological and climatological observations were made hourly. Eventually the electric tram traffic in the neighbourhood of the Observatory disturbed the measurements and the readings ceased in 1912.

Magnetic equipment

The instruments for continuous monitoring of geomagnetic variations at the Helsinki observatory were manufactured in Göttingen, Germany.. The principles of the observatory magnetometers were invented by Carl Friedrich Gauss in 1836-1837 and described in the proceedings of the Göttingen Magnetic Union (Gauss, 1838). Gauss was the leading scientist in the field of geomagnetism and inventor of many geomagnetic instruments with his colleague Wilhelm Weber. The observatory routines in Helsinki were also based on those of the Göttingen observatory.

There were three magnetic vector components to be observed: the horizontal field (H), the declination (D), and the vertical component (Z). D is the angle between the H-vector and the true magnetic north direction.

As an example, fig. 5 shows the magnet for D- and H-observations. Similar types of magnets as that in Göttingen were in use in all magnetic observatories through the 19th century. The weight of the magnet was 1,8 kg and the dimensions were 63 cm x 3,7 cm x 1 cm. For D-measurements, the magnet was in the same direction as the H-vector pointing thus towards the magnetic north. For H-observations the position of the magnet was perpendicular to the H-vector in the east-west direction. The changes in the direction of the magnet were observed by a telescope on a scale reflected by a mirror fixed to the magnet, fig. 5. The distance between the magnet and the telescope was about 7 meters.

Historical background

After the war between Sweden-Finland and Russia, 1808-1809, Finland was annexed to Russia as an autonomous Grand Duchy. Russia had a positive policy towards Finland and the university benefited from it. The capital was also moved from Turku to Helsinki in 1812. After the Great Fire in Turku in 1827 the university was moved to Helsinki, and re-established in the new city centre under the name of the Imperial Alexander University in Finland.

Essentially the same observational procedure and equipment were in use in all magnetic observatories for about 150 years. Photographic recording systems came in during the late 19th century. Since about 1970s all geomagnetic observatories have been equipped with magnetic recording instruments without magnets, for example using protonmagnetometers or flux-gate instruments.

Johan Jakob Nervander (1805-1848

1805 • Johan Jacob Nervander was born on 23 February 1805 in Uusikaupunki (Nystad). His father was a pharmacist and merchant (owning partnerships in merchant ventures). However, these speculations turned to economical ruin, and he had to sell the pharmacy rights, whereafter the family moved to Oulu (Uleåborg).

1820 • Having passed the primary school in Oulu and the cathedral school in Turku Nervander, at the age of 15, passed his matriculation exams and entered the academy in Turku.

1827 • Nervander finished his *pro gradu* thesis and obtained his M.Sc. The matriculation score, 30 out of 33, was the best result ever recorded at the Academy.

1829 • Nervander wrote a dissertation for a docentship and was appointed the same year. He was also acting professor of physics during the period when Hällström was rector of the university in Helsinki.

1832-1836 • Nervander travelled to several research centres and universities in Europe. He constructed the *tangentbussol* and lectured on this device, thereby earning an international reputation as a physicist.

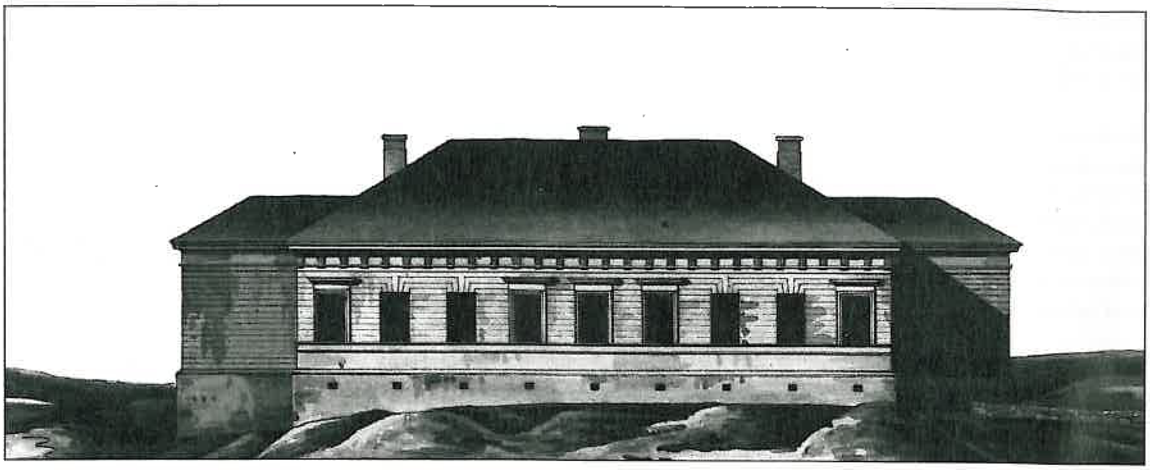
1838 • A magnetic observatory was founded in Helsinki and Nervander was appointed its first director. Nervander also took part in establishing the Finnish Society of Sciences and Letters and was elected president for the year 1847.

1844 • Continuous measurements of variations in the magnetic field of the Earth and normal meteorological observations were begun in the Helsinki Observatory.

1845 • Nervander was appointed professor of physics after the death of Hällström.

1848 • Nervander falls ill with smallpox and dies on March 15.

1991-1996 • The measurement of the magnetic field, started by Nervander, continued for almost 70 years until 1911, when the electric tram traffic in the neighbourhood disturbed these measurements too much. Today this large amount of material which was collected has been analysed and finally published by the FMI's team (Nevanlinna, 2004). The work that Nervander had begun some 160 years previously has thus been completed. The Helsinki magnetic data series is scientifically very valuable, because not much high-quality magnetic data are preserved from other observatories around the world from the middle of the 19th century. The Helsinki data give useful information about geomagnetic variations connected with the long-term changes of the activity of the Sun.



◄ Fig. 3: The main building of the Helsinki Observatory in 1838

The Helsinki magnet, manufactured in Göttingen in 1841 is still suspended from the roof of the lobby of the Finnish Meteorological Institute, demonstrating the changing magnetic field as it did for so long.

The end of the Nervanda era

Nervander also studied climatology, especially the question of how sunspots affect the temperature in the atmosphere. This work won a prize from the Russian Science Academy in St. Petersburg. In the midst of his success Nervander fell ill with smallpox and suddenly died on 15 March 1848. After that Henrik Gustaf Borenius, Nervander's son - in - law, became the Director and the activities at the Magnetic Observatory continued, but without publication.

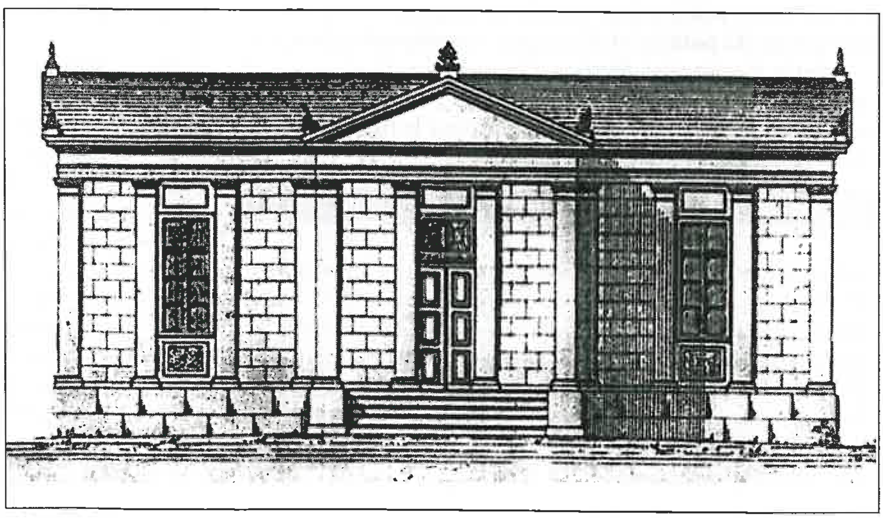
The importance of magnetic measurements

The magnetic declination and the intensity of the horizontal component of the Earth's magnetic field and, in the beginning, also the vertical component, were noted. The readings from the first period when Nervander was Director were published posthumously in 1850 with an introduction by Borenius. After that, only readings without analysis were made and the number of laboratory journals steadily increased. These journals have only now, in recent times, been found; they are now available in the Archive of the Finnish Meteorological institute (FMI) in Helsinki.

In the 1990s, Dr. Heikki Nevanlinna and his team in the FMI converted the handwritten numbers into electronic form. They carefully analyzed this old material, consisting of about 2,000,000 single readings, and published the results for the full period 1844-1911. Thus the work begun more than 160 years ago by Nervander, and continued under supervision by many Directors thereafter, has finally been completed (Fig. 6).

Long, continuous and homogeneous data series are extremely important when studying slow changes in the geomagnetic field, the so-called secular variation, giving clues to the physical mechanisms sustaining the geomagnetic field inside the Earth. The Helsinki series covers about 70 years.

► Fig. 4: A building (Absolute House) for calibration of geomagnetic observatory instruments. It was in operation 1845-1920.



Transient geomagnetic variations lasting from minutes to days are connected with so-called space weather which characterizes electromagnetic conditions in the near-space around the Earth, in the iono- and magnetospheres. The space weather is ultimately governed by the activity of the Sun, manifested by varying solar corpuscular and electromagnetic radiations. By this means, magnetic observatory recordings give indirect information about the processes regulating the solar energy output. Long-term observations of the space weather indicators tell about slow changes in the solar radiation in the course of 11-year sunspot cycles. For such studies, the Helsinki series provides an outstanding data source covering about six solar cycles. The daily magnetic field values are usually converted into indices (numbers) in a standardized scale, making comparisons of magnetic variations between different observatories possible. The longest of such a series is known as the *aa*-series, starting in 1868 and continuing into the present. It is based on combined observatory recordings in England and Australia. The index series, derived from the Helsinki magnetic observations, yields information about solar activity for 24 years before the start of the *aa*-index series. Thus, the combined *aa*-Helsinki magnetic activity index series covers about 160 years since 1844. During the last 10 years about 40 scientific articles have appeared utilizing the newly available magnetic observations from Helsinki.

The Magnetic Observatory after Nervander

When Borenius, Nervander's son-in-law and successor as Director, withdrew from this position in 1880, the Finnish Society

◄ Fig. 5: The great magnet for monitoring changes in horizontal field and declination at the Helsinki observatory (1844-1912). The length of the magnet is about 60 cm and the weight almost 2 kg. Changes in the direction of the magnet were observed through a telescope, at 7 meters distance, that was pointing to the mirror shown above the magnet fixed in the suspension wire.

of Sciences and Letters took over the responsibility for the Observatory. Nils Karl Nordenskiöld, Ernst Biese and Gustaf Melander followed as Directors. During Melander's leadership (1908-1918) the Observatory was reorganised and separated from the Finnish Society of Sciences and Letters, becoming the Meteorological institute, an independent state institute.

So the interest in geomagnetism has long and inspiring traditions in Finland. When the International Geophysical Polar Year (1882-1883) was planned, Karl Selim Lemström (1838-1904), Professor of Physics, was an eager spokesman in support for Finland's participation, due to his advocacy, a temporary magnetic-meteorological observatory was founded in Sodankylä, northern Finland, with six assistants. With this polar station, Finland now took a position among other nations in the scientific community.

The FMI, as the successor of the Helsinki Magnetic Observatory, maintains a permanent magnetic observatory in Nurmijärvi near Helsinki. Another observatory is in Sodankylä, Lapland, under the University of Oulu. In addition, the FMI runs a network of automatic magnetometers monitoring the magnetic component of space weather variations. The network consists of 6 magnetometers in Finland and 21 in other parts of Fennoscandia from Estonia to Svalbard in the Barents Sea. Geomagnetic research is devoted to magnetospheric phenomena and space weather effects on the ground. The spirit of Nervander lives on. ■

About the authors

Peter Holmberg (b. 1938), Emeritus Professor, teaches medical physics in the Faculty of Medicine, University of Helsinki. His research interests are in the field of radiation physics and radiology. He has also written textbooks on physics and biophysics. For many years he has been interested in the history of physics and he has written *The History of Physics in Finland* 1828-1918 and several articles on this topic.

Heikki Nevanlinna (b. 1947), PhD, works as Research Manager at the Space Research unit in the Finnish Meteorological Institute. His scientific expertise focuses on the Earth's magnetic field variations and space weather phenomena including Northern Lights. He has written about100 scientific papers and in recent years also many popular articles on geophysical topics.

Further reading

Gauss, C.F. - 1838. Bemerkungen über die Einrichtung und den Gebrauch des Bifilar-Magnetometers. In: Resultate aus den Beobachtungen des magnetischen Vereins im Jahre 1837 (Eds. C.F. Gauss & W. Weber), p. 20-37.

Holmberg, P. - 1992. The history of physics in Finland 1828-1918. The History of Learning and Science in Finland 1828-1918, 5a, Societas Scientiarum Fennica, Helsinki, 267 p.

Holmberg, P. - 1998. Johan Jakob Nervander och det Magnetiska Observatoriet i Helsingfors. Arkhimedes 6, 22-26.

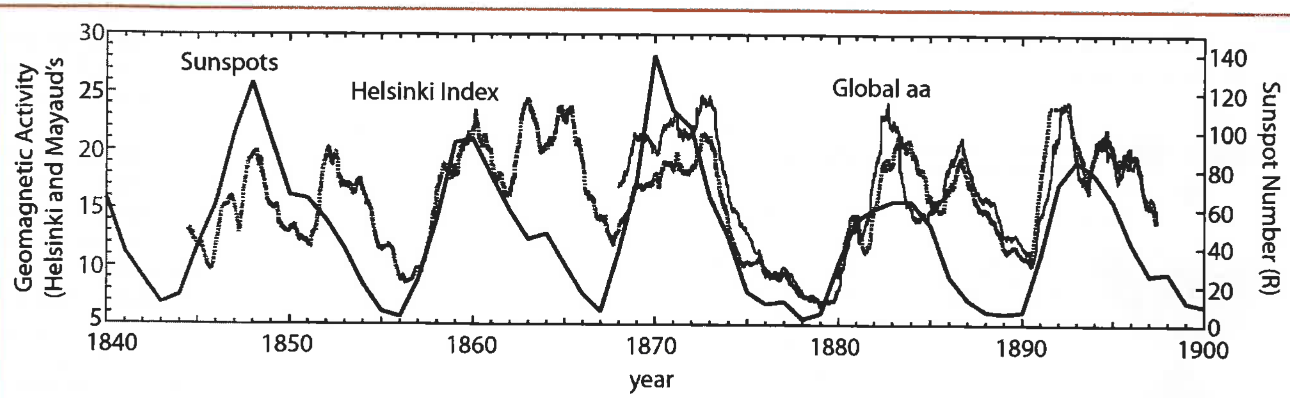
Holmberg, P. - 2003. Northern Light Studies and Geomagnetic Observations in Finland in the 19th Century. In: Volta and the History of Electricity (Eds. Fabio Bevilacqua and Enrico A. Giannetto), p. 183-192.

Nevanlinna, H. - 1995. New geomagnetic activity index series published for 1844-1880. EOS, Transaction, American Geophysical Union, 76, 233-234.

Nevanlinna, H. - 1997. Gauss' H-Variometer at the Helsinki Magnetic Observatory (1844-1912). Journ. Geomagn. Geoelectr. 49, 1209-1216.

Nevanlinna, H. - 2004. Results of the Helsinki magnetic observatory 1844-1912. Ann. Geophys., 22, 1691-1704.

Simojoki, H. - 1978. The history of geophysics in Finland 1828-1918. The History of Learning and Science, 5b, Societas Scientiarum Fennica, Helsinki, 157 p.



▲ Fig. 6: Dotted line: Magnetic activity index derived from the Helsinki observations 1844-1897.
Thin solid: The longest available global index (*aa*) starting in 1868. • Thick solid: Sunspots in the 11-year solar cycle